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# THE AMERICAN METEOROLOGICAL JOURNAL.

*A MONTHLY REVIEW OF METEOROLOGY.*

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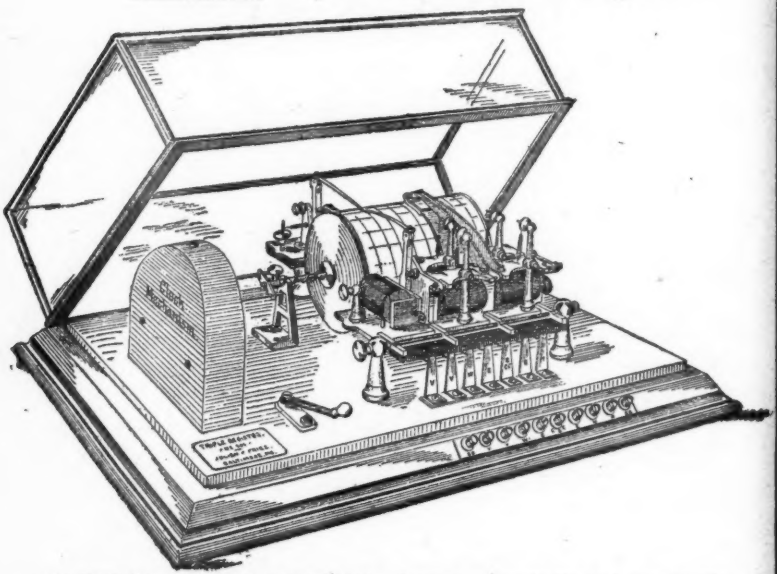

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VOL. XI. BOSTON, MASS., AUGUST, 1894. No. 4.

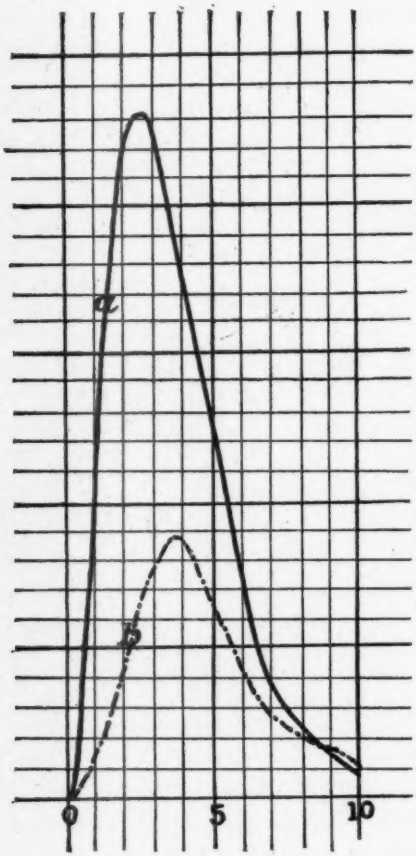
## FREQUENCY OF AMOUNTS OF PRECIPITATION.

PROF. MARK W. HARRINGTON.

METEOROLOGISTS have all but universally adopted the arithmetic mean as the representative value for series of observations. Where the theory of errors applies, — as in astronomic observations generally, — the arithmetic mean is also the most frequent, and, hence, the most probable, value. Silence concerning the nature of these means in meteorology has permitted the impression, on the part of readers rather than on that of the meteorologist, that they are like most astronomic and many other means, in being most probable values. In meteorology this is rarely the case — or rather it is necessary to distinguish when this is true, and when not. For instance, if the average rainfall for May at a given station is three inches, it is by no means correct to say that for any future May the rainfall is as likely to be more than three inches as it is to be less. In every case of monthly rainfalls that I have examined is this correct. The most probable value has generally been considerably less than the mean.

The reason for this difference is easily found. The most frequent (hence, most probable) value relates solely to the relative number of times of recurrence of certain individual values; the arithmetic mean relates to quantities — total quantities for the day, month, season, or year. The question with the first is, what is the probability of any given amount in the future, and this is measured by occurrences in the past. The question with the second is the average depth of rainfall, and this is measured by summing all and dividing by the number. Graphically, if in the diagram, *a* is the curve of frequency, and *b* the curve obtained

by multiplying the frequency at each ordinate by the abscissa (which is the amount for each occurrence), then the most probable (*i. e.*, the most frequent) value is the abscissa for the maximum of *a*, and the mean is the abscissa for the centre of gravity of *b*.




Though curve *a* gives the most probable value, it does not correspond to the familiar probability curve of the theory of errors, and for an obvious reason. The theory of errors requires that equal negative and positive departures from the mean shall be equally probable. There must, therefore, within the reach of the branches of the curve, be limits symmetrical with its axis. In the case of curve *a* there is a lower limit at the origin and no corresponding one on the opposite side of maximum ordinate. The same is true of curve *b*. To neither of these curves, and to no curve without symmetrical limits, can the ordinary theory of errors be applied. Hence the deduction of probable errors or mean errors of such meteorologic means is vain, and the result illusory.

Applying these principles to the data of precipitation we find that the results are very variable — so variable that no single series of records available gives a smooth and satisfactory curve. To obviate this I have combined the observations at several sta-

tions where the rainfall regimen is very similar, and the different months, when the rainfall is scattered with good uniformity through the months. In this way are obtained the equivalents of very long series, and we can thus ascertain the character of the curve of frequency, while we lose only the direct application to single stations.

For the daily rainfall the stations Albany, Boston, New London, New Haven, New York, and Philadelphia were selected. The data had been compiled for other purposes and the abscissas do not increase uniformly. A curve cannot, therefore, be directly drawn from the table, but the relation of most frequent and mean daily rainfalls is sufficiently evident. The results are given in Table I. They relate only to rainy days (on which a trace or more of rain fell), and cover about 120 years or 20,000 rainy days. The most probable value for any rainy day is about .125 inch, and the mean value about .280. The latter is more than twice the former.

TABLE I.

FREQUENCY OF DAILY RAINFALLS IN PERCENTAGES.

(Six stations combined.)

| INCHES. | WINTER. | SPRING. | SUMMER. | AUTUMN. | YEAR. |
|---|---|---|---|---|---|
| Trace to 0.25 . . . . . | 69 | 69 | 66 | 67 | 68 |
| 0.26 to 0.50 . . . . . | 15 | 14 | 14 | 15 | 14 |
| 0.51 to 1.00 . . . . . | 12 | 12 | 12 | 11 | 12 |
| 1.01 to 2.00 . . . . . | 4 | 4 | 7 | 6 | 5 |
| 2.01 to 3.00 . . . . . | 0 | 1 | 2 | 1 | 1 |
| 3.01 to 5.00 . . . . . | 0 | 0 | 0 | 0 | 0 |
| 5.01 + . . . . . | 0 | 0 | 0 | 0 | 0 |

For the monthly values, the long series of observations at Troy, Waltham, New Bedford, New Haven, New York, and Philadelphia were selected. The combined number of years is 370 or more, differing slightly for different months. That it is not unsafe, for the present purpose, to combine the monthly values for the different months and stations is shown by Table II., where the extreme months may be compared. The most frequent number

for January and July is 2.6; the means, for January, 3.35, for July, 3.78.

TABLE II.

Frequency of Monthly Precipitation.

*January*, 371 *years.*

| Inches. | Troy, N. Y. | Waltham, Mass. | New Bedford, Mass. | New Haven, Conn. | New York, N. Y. | Philadelphia, Penn. | Sum in Percentages. | Relative Quantity. |
|---|---|---|---|---|---|---|---|---|
| 0.5 | 6 | 3 | 2 | 0 | 3 | 2 | 4 | 2.0 |
| 1.5 | 17 | 13 | 9 | 5 | 8 | 12 | 17 | 25.5 |
| 2.5 | 22 | 18 | 18 | 7 | 15 | 19 | 27 | 67.5 |
| 3.5 | 9 | 12 | 20 | 11 | 8 | 10 | 19 | 66.5 |
| 4.5 | 9 | 8 | 11 | 13 | 9 | 12 | 17 | 76.5 |
| 5.5 | 2 | 8 | 8 | 2 | 11 | 5 | 10 | 55.5 |
| 6.5 | 1 | 4 | 6 | 2 | 2 | 1 | 4 | 26.0 |
| 7.5 | – | 1 | 1 | 1 | – | 2 | 1 | 7.5 |
| 8.5 | – | – | 3 | – | – | – | 1 | 8.5 |
| Years. | 66 | 67 | 78 | 41 | 56 | 63 | 100 | 335.5 |

*July*, 376 *years.*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0.5 | 0 | 0 | 3 | 1 | 0 | 0 | 1 | 0.5 |
| 1.5 | 6 | 10 | 23 | 8 | 12 | 6 | 17 | 25.5 |
| 2.5 | 14 | 24 | 18 | 4 | 17 | 16 | 25 | 62.5 |
| 3.5 | 12 | 12 | 13 | 6 | 11 | 12 | 18 | 63.0 |
| 4.5 | 13 | 5 | 9 | 13 | 6 | 13 | 16 | 72.0 |
| 5.5 | 10 | 7 | 4 | 2 | 5 | 7 | 9 | 49.5 |
| 6.5 | 8 | 4 | 6 | 5 | 1 | 4 | 8 | 52.0 |
| 7.5 | 2 | 2 | 0 | 1 | 1 | 2 | 2 | 15.0 |
| 8.5 | 0 | 1 | 1 | 1 | 2 | 1 | 2 | 17.0 |
| 9.5 | 1 | 2 | 0 | 1 | 0 | 1 | 1 | 9.5 |
| 10.5 | – | 0 | 1 | 0 | 0 | 0 | 0 | – |
| 11.5 | – | 1 | – | 2 | 1 | 1 | 1 | 11.5 |
| 12.5 | – | – | – | 0 | – | – | 0 | – |
| 13.5 | – | – | – | 0 | – | – | 0 | – |
| 14.5 | – | – | – | 0 | – | – | 0 | – |
| 15.5 | – | – | – | 0 | – | – | 0 | – |
| 16.5 | – | – | – | 0 | – | – | 0 | – |
| 17.5 | – | – | – | 1 | – | – | 0 | – |
| Years. | 66 | 68 | 78 | 45 | 56 | 63 | 100 | 378.0 |

The combined results by season and year (actual count and percentages) are given in Table III., giving for each season over 1,100, and for the year 4,500 months. The results are very smooth. The most frequent value is about 2.6 inches for each season, but computation gives for the arithmetic mean 3.34;

3.54; 3.71; 3.52, and 2.53 in the order of the table. It is interesting to note that, over the area covered by these stations (in the northeastern United States) though the monthly amounts of rainfall vary somewhat, it is safe to assert for any month that the rainfall is likely to be 2.6 inches, and that the probability is about two to one that the rainfall of any month will be below the annual mean.

TABLE III.

FREQUENCY OF MONTHLY PRECIPITATION.

By Seasons and the Year.

| Inches. | Winter. | | Spring. | | Summer. | | Autumn. | | Year. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Actual Numbers. | Per cents. | Actual Numbers. | Per cents. | Actual Numbers. | Per cents. | Actual Numbers. | Per cents. | Actual Numbers. | Per cents. |
| 0.5 | 52 | 5 | 52 | 5 | 41 | 4 | 44 | 4 | 189 | 4 |
| 1.5 | 186 | 16 | 157 | 14 | 174 | 16 | 202 | 18 | 719 | 16 |
| 2.5 | 284 | 25 | 280 | 25 | 238 | 21 | 256 | 23 | 1058 | 23 |
| 3.5 | 247 | 22 | 249 | 22 | 214 | 19 | 223 | 20 | 933 | 21 |
| 4.5 | 188 | 17 | 161 | 14 | 178 | 16 | 169 | 15 | 696 | 15 |
| 5.5 | 100 | 9 | 116 | 10 | 114 | 10 | 103 | 9 | 433 | 10 |
| 6.5 | 41 | 4 | 56 | 5 | 73 | 7 | 62 | 5 | 232 | 5 |
| 7.5 | 15 | 1 | 28 | 3 | 39 | 3 | 30 | 3 | 112 | 3 |
| 8.5 | 6 | 1 | 16 | 1 | 23 | 2 | 23 | 2 | 68 | 2 |
| 9.5 | 1 | – | 7 | 1 | 16 | 1 | 7 | 1 | 31 | 1 |
| 10.5 | – | – | 1 | – | 4 | 0 | 8 | 1 | 13 | – |
| 11.5 | – | – | – | – | 9 | 1 | 0 | – | 9 | – |
| 12.5 | – | – | – | – | 0 | – | 2 | – | 2 | – |
| 13.5 | – | – | – | – | 0 | – | 2 | – | 2 | – |
| 14.5 | – | – | – | – | 1 | – | – | – | 1 | – |
| 15.5 | – | – | – | – | 1 | – | – | – | 1 | – |
| 16.5 | – | – | – | – | 2 | – | – | – | 2 | – |
| Number | 1120 | 100 | 1123 | 100 | 1127 | 100 | 1131 | 101 | 4501 | 100 |

The larger amount in summer is due to the introduction of rainfall from a new source, — that of local storms. The winter rainfall is from general storms almost exclusively, but in the summer we have the local storms added. These are the storms which give the torrential precipitation when it occurs, and consequently we find distinct indications of a secondary maximum of frequency in summer and some traces of it in autumn and spring.

The signs of a second maximum are much more distinct in the monthly rainfalls for Charleston, S. C. (Table IV.). They are here so strong that they appear in the summation for the year. There are even three secondary maxima in the curve of frequency for summer, but these would probably be reduced to one if we had a series of observations ten times as long.

TABLE IV.

CHARLESTON, S. C.

Frequency of Monthly and Annual Precipitation for Sixty-two Years.

| Monthly Precipitations. | | | | | | Annual. | |
|---|---|---|---|---|---|---|---|
| Inches. | Winter. | Spring. | Summer. | Autumn. | Year. | Inches. | Number of Times. |
| 0.5 | 18 | 28 | 4 | 31 | 81 | – | – |
| 1.5 | 42 | 38 | 18 | 33 | 131 | 21–25 | 1 |
| 2.5 | 47 | 34 | 16 | 23 | 120 | 26–30 | 2 |
| 3.5 | 29 | 25 | 18 | 33 | 105 | 31–35 | 4 |
| 4.5 | 27 | 24 | 24 | 17 | 92 | 36–40 | 9 |
| 5.5 | 11 | 17 | 20 | 15 | 63 | 41–45 | 11 |
| 6.5 | 5 | 8 | 19 | 9 | 41 | 46–50 | 15 |
| 7.5 | 5 | 7 | 19 | 7 | 38 | 51–55 | 8 |
| 8.5 | 0 | 2 | 9 | 6 | 17 | 56–60 | 4 |
| 9.5 | 1 | 2 | 16 | 3 | 22 | 61–65 | 3 |
| 10.5 | 1 | 0 | 9 | 2 | 12 | 66–70 | 2 |
| 11.5 | – | 0 | 2 | 4 | 6 | 71–75 | 0 |
| 12.5 | – | 0 | 5 | 1 | 6 | 76–80 | 3 |
| 13.5 | – | 0 | 1 | 0 | 1 | | — |
| 14.5 | – | 0 | 0 | 2 | 2 | | 62 |
| 15.5 | – | 1 | 4 | – | 5 | | |
| 16.5 | – | – | 1 | – | 1 | | |
| 17.5 | – | – | 0 | – | 0 | | |
| 18.5 | – | – | 0 | – | 0 | | |
| 19.5 | – | – | 1 | – | 1 | | |

For the annual rainfall the results for the six stations (Troy, Waltham, New Bedford, New Haven, New York, and Philadelphia) are given in Table V., — for each five inches only, to make the table more compact and emphasize the general features of the curve. The most frequent value is 38.0 inches ; the mean value, 41.6 inches. The annual frequencies for Charleston are given in Table IV. In this the most frequent value by count is 44 inches, by curve 46 ; while the actual mean is 48.1 and that by the curve 47.3.

TABLE V.

FREQUENCY OF ANNUAL PRECIPITATIONS.

| Inches of Precipitation per Year. | Actual Number of Times. | Percentages. | Resulting Annual Amounts. |
|---|---|---|---|
| 16–20 | 1 | 0 | |
| 21–25 | 2 | 1 | 22.5 |
| 26–30 | 15 | 4 | 110.0 |
| 31–35 | 45 | 12 | 390.0 |
| 36–40 | 101 | 28 | 1050.0 |
| 41–45 | 96 | 26 | 1105.0 |
| 46–50 | 54 | 15 | 712.5 |
| 51–55 | 33 | 9 | 472.5 |
| 56–60 | 12 | 3 | 172.5 |
| 61–65 | 8 | 2 | 125.0 |
| 66–70 | 0 | 0 | |
| | 367 | 100 | 4160.0 |

The form of the simple curves of frequency, when cases of no rain are excluded, is that of the right-hand branch of a cubic with an equation of the form

$$a\,x + b\,x^2 + c\,x^3 + d = y.$$

This is an awkward equation to solve (for the co-efficients) by the method of least squares as such a solution involves all the powers of $x$ up to and including the sixth. A close approximation to the point of maximum may, however, be obtained by dropping the term with $x^3$, when by proper selection of the origin, etc., the above equation becomes the parabola

$$ax + bx^2 = y,$$

and in the normal equations the odd powers of $x$ sum up zero, making the solution very simple.

If secondary maxima are taken into account, then a sinuous curve would result, with an equation of the same character as the second preceding, but more complicated and less manageable.

When the days, months, etc., of no rainfall are included, the curve of frequency takes on a form which appears different from the preceding. This is best illustrated in daily rainfalls when, for the United States, the percentages for zero rainfalls are generally over 50. It is also illustrated in the monthly values in

places having well-marked rainy seasons. This appears in Table VI., giving the frequencies of monthly rainfalls in the dry season for three stations in India having long series of observations.

TABLE VI.

Frequency of Monthly Rainfalls in Dry Season.

| Inches of Monthly Rainfall. | Madras. Jan. to April inc. | Calcutta. Nov. to Feb. inc. | Bombay (Colaba). Nov. to May inc. | Combined Percentages. |
|---|---|---|---|---|
| 0.00 | 153 | 114 | 200 | 58 |
| 0.01–0.99 | 97 | 70 | 68 | 29 |
| 0.5 | 250 | 184 | 268 | 87 |
| 1.5 | 21 | 25 | 7 | 7 |
| 2.5 | 9 | 14 | 2 | 3 |
| 3.5 | 6 | 6 | 0 | 1 |
| 4.5 | 4 | 2 | 0 | 1 |
| 5.5 | 1 | 1 | 3 | 1 |
| 6.5 | 4 | – | – | – |
| 7.5 | 0 | – | – | – |
| 8.5 | 1 | – | – | – |
| Number of Months | 296 | 232 | 280 | |
| Number of Years | 74 | 58 | 40 | |

The most frequent monthly precipitation is here zero, as shown in the first line of the table, but the mean precipitation is about 0.06, with a frequency only one fourth or one fifth that of zero.

The curve in these cases is the right-hand part (beyond the maximum) of that of the preceding cases, and the left-hand part has no physical significance. This curve could be expressed also by a hyperbolic equation of simple form.

The annual rainfalls generally become so large that the curve is far removed from the lower limit, viz., zero. They in so far approximate the conditions of astronomic measurements, and the requirements of the theory of errors and the frequencies can profitably be treated as is habitually done in the latter. This is best done by the departures from the mean, and not by the amounts in quantity. This makes a curve which is somewhat

more easily interpreted. I have inspected all the long series of rainfall observations which are available in the library of the Weather Bureau, and append the list to this paper. The inspection shows that the curves of departures from the annual means always approximate the probability curve when the series of observations is sufficiently long; but always differ in one respect which is fundamental. The large departures on the positive side are more probable than on the negative side. A fundamental requirement for the curve of probability is that positive and negative departures of equal magnitude shall be equally probable. Occasional very heavy rains, — such as torrential rains, cloudbursts, etc., — are consequences of occasional combinations of atmospheric forces everywhere, except, perhaps, in very high latitudes. This introduces a systematic difference between the probability curve and the curve of rainfall frequency which cannot be eliminated by increasing the length of the series of observations.

The preceding discussion should make it evident that in rainfall statistics the means are not the only instructive representative values. The most probable (or most frequent) value is also of interest and use. It shows what the rainfall is likely to be in the future, and is nearly always less than the mean, most different from the last in the daily values, and least in the annual. The discussion also shows that the curve of rainfall frequency is fundamentally different from the probability curve, and hence deductions, on the principles of the latter, of the probable or mean departures are valueless. Corresponding expressions could be used, but the numbers would differ on the opposite sides of the axis. Perhaps the greatest known departure would be most useful, and it might be written thus: —

Charleston; annual rainfall $48.1 \left\{ \begin{matrix} -24.4 \\ +30.3 \end{matrix} \right\}_{62}$ in inches; or

St. Petersburg, $464.5 \left\{ \begin{matrix} -157.8 \\ +305.1 \end{matrix} \right\}_{66}$ or,

Milan, $992.6 \left\{ \begin{matrix} -353.2 \\ +581.0 \end{matrix} \right\}_{112}$

the two latter in millimeters, the small figures below and to the right giving the length of the series, or the number of values compared.

## LIST OF REFERENCES

To Series of Rainfall Observations of Fifty or More Years in the Library of the U. S. Weather Bureau.

Angot, Alfred. "Valeurs normales de la température, de la pression et de la pluie a Paris." (1841–1890.) Ann. bur. centr. met., Par., i Mém., 1890. p. B. 129–B. 160.

Bergholz, Paul. "Ergebnisse der meteorologischen Beobachtungen in Bremen von 1803 bis 1890." Jahrg. i. 4to. Bremen, 1891. xi, 40 p. 8 pl.

Binnie, Alexander Richardson. "On mean or average annual rainfall, and the fluctuations to which it is subject." (Rainfall at Padua from 1725 to 1821. p. 35–37. Tables i. & ii.) 8vo. Lond., 1892.

(Extreme variations from the mean rainfall of different shorter periods when compared with the mean of the total period. Derived from 42 records of from fifty to ninety-seven years. Table iv. p. 40–41.) (The same: Derived from 26 records of from fifty to sixty years. Table v. p. 42–43.)

Birkner, Oscar. "Ueber die Niederschlagsverhältnisse des Königreichs Sachsens." (Dresden, 1828–1884; Freiberg, 1830–1884.) Jahrb. k. sächs. met. Inst., Chemnitz, 1885. Anh. i, p. 6–25.

Blanford, Henry F. "The Rainfall of India." (Contains long series of observations for Calcutta, 1829–1883; Bombay, 1817–1883; Madras, 1813–1883.) Indian met. mem., Calc., iii, 1886–88. 658 p. 19 pl.

Cleaveland, Parker. "Results of Meteorological Observations made at Brunswick, Maine, between 1807 and 1859." (Smithson. contr. to knowl., 204.) 4to. Wash., (1867). 53 p.

Descroix, Leon. "Climatologie Parisienne." (Containing observations from 1699–1891.) Annuaire Obs. Montsouris, Par., 1892–93, p. 70–191.

Drechsler, Adolph. "Ergebnisse von fünfzigjährigen Beobachtungen der Witterung zu Dresden." (1828–1878.) fol. Dresden, 1879. xxxiv., 17 p. 4 pl.

Fritsch, Karl. "Grundzüge einer Meteorologie für den Horizont von Prag." (Containing rainfall observations. 1771–1846.) 4to. Prag, 1850. 179 p.

Gale, James M. "The Rainfall at Mountstuart and Rothesay from 1800 to 1875." J. Scot. Met. Soc., Edinb. & Lond., n. s., v. 1880, 21–22.

Garibaldi, Maria. "Contribuzione alla climatologia di Genova." Temperatura e pioggia nel sessantennio 1833–1892. (Extr. from: Atti soc. ligust. di scinat., iv. anno, iv. vol.) 8vo. Genova, 1893. 28 p. 3 tabl.

Glaisher, James. "On the Fall of Rain on every Day of the Year from Observations Extending from 1815 to 1869." Pr. met. soc., Lond., v, 1869–71, p. 87–122.

Hann, J. "Untersuchungen über die Regenverhältnisse von Oesterreich-Ungarn." Tabelle ii. (Uebersicht jener Orte in Oesterreich-Ungarn [und einiger Grenzorte] von denen bis Ende 1878 längere Reihen von Regenmessungen vorlagen.) (1817–1878.) Extr. from: Sitzungsb. Akad. Wiss., Wien, lxxx, Oct. 1879.

Lais, Giuseppe. "Atlante meteorico ossia riassunto grafico generale delle variazioni atmosferiche del clima di Roma." (1776–1883.) 4to. Roma, 1885. 35 p. 17 pl.

Lamont, J. "Beobachtungen des meteorologischen Observatoriums auf dem Hohenpeissenberg." (1792–1864.) (Suppl. Bd. zu den Annalen der Münch. Sternwarte.) 2 v. 8vo. Münch., 1851. lxx, 787 p.; 1868, xxxix, 210 p.

LANG, CARL. "Das Klima von München, nach siebenundsechzigjährigen Beobachtungen." 4to. Münch., 1883. xiii, 33 p. 4 pl.

MORRISVILLE, PA. "Rainfall at Morrisville, Pa., with continuation at Fallsington." (1825–1887.) Ann. rep. sec. intern. affairs Harrisb., Pa., 1888. p. A 169–A 170.

MÜNCHEN. K. MET. CENTRAL-STATION. "52jährige Beobachtungen zu Augsburg." (1812–1878.) Beob. met. Stationen im Königreich Bayern, ii, 1880, p. 165–184.

"Siebenundsechzigjährige Beobachtungen zu München." (1781–1880.) Beob. met. Stationen im Königreich Bayern, iv, 1882, p. 169–201.

PLANTAMOUR, E. "Nouvelles études sur le climat de Genève." (Tables of Observations from 1826–1875.) 4to. Genève-Bale-Lyon, 1876. 263 p.

POLIS, P. "Zur Klimatologie Aachens." Resultate der in den Jahren 1829–1889 angestellten meteorologischen Beobachtungen. 4to. Aachen, 1890. 13 p. 28 tabl. 1 ch.

RAULIN, V. "Sur les observations pluviométriques faites dans la Bretagne (ouest de la France) de 1785 à 1870." Extr. from: Actes ac. sci., Bordeaux, 1878 (1881). p. 605–860. 2 pl.

RAULIN, V. "Sur les observations pluviométriques faites dans la Neustrie (Plaine de la France septentrionale) de 1688 à 1870." Ann. bur. centr. met., Par., i, 1879. p. B. 13–B. 37.

RENOU, E. "Etudes sur le climat de Paris." Deuxième partie. — La pluie depuis 1688 (à 1885). Ann. bur. centr. met., Par., i, 1885. p. B. 259–B. 277.

RIGGENBACH, ALBERT. "Die Niederschlags-Verhältnisse von Basel." (1755–1888.) 4to. Zürich, 1891. 32, (78) p. 2 pl.

ROMA. "Ufficio Centrale di Meteorologia Italiana." (Tables of monthly rainfall: Milano, 1764–1879; Venezia, 1836–1879; Verona, 1822–1879; Padova, 1725–1879; Chioggia, 1771–1879; Pavia, 1812–1879; Parma, 1833–1879; Modena, 1830–1879; Bologna, 1813–1879; Genova, 1833–1879; Firenze, 1832–1879; Roma, 1825–1879; Napoli, 1821–1879; Locorotondo, 1829–1879; Palermo, 1806–1879.) Ann. uff. centr. met., Roma, ii. ser., vol. iii, pt. i, 1881. p. 20–120.

SCHOTT, CHARLES A. "Tables and results of the precipitation, in rain and snow, in the United States." (Smithson. contr. to knowl., 353.) (Annual amount of aqueous precipitation. New Bedford, Mass., 1814–1874; Marietta, Ohio, 1818–1874; Morrisville, Pa., 1825–1874; Philadelphia, Pa., 1824–1876.) fol. Wash. 1881.

SCHOUW, J. F. "Tableaux du climat de l'Italie." vol. i. — Tableau de la température et des pluies de l'Italie. (1657–1832.) 8vo. Copenh., 1839. 227 p. 5 pl.

SYMONS, G. J. "On the distribution of rain over the British Isles during the year 1891." (Recent annual rainfall compared with the previous 165 consecutive years.) p. 16–18, 1 pl. Symons's British Rainfall, 1891.

TIDBLOM, A. V. "Einige Resultate aus den meteorologischen Beobachtungen angestellt auf der Sternwarte zu Lund in den Jahren 1741–1870." (Extr.: Lunds Universitets Arsskrift, xii.) 4to. Lond., 1876. 75 p. 2 pl.

TOALDO, D. GIUSEPPE. "Della vera influenza degli astri sulle stagioni e mutazioni di tempo saggio meteorologico." (Tavola ii. Della pioggia caduta in Padova in pollici e decimali del pie di Londra.) (1725–1780.) 4to. Padova, 1781.

WAGNER, COLEMAN. "Niederschläge und Gewitter zu Kremsmünster." (Rainfall, 1821–1887.) 8vo. Linz, 1888. 34 p.

Wien, K. K. Sternwarte. "Meteorologische Beobachtungen an der K. K. Sternwarte in Wien von 1775 bis 1855." 5 vols. 8vo. Wien, 1860–1866. The same: 1856–1874. (Aus den Annalen k. k. Sternw., Wien, vii, 1857–xxiv, 1875.) 1 v. 8vo. Wien. (1857–1875.)

Wigert, Thure. "Quantité de pluie pendant les années 1739–1890." (Upsal.) Bull. mens. obs. met. univ. d'Upsal. Append. Recherches sur le climat d'Upsal. i. Pluies. 4to. Upsal, 1893. p. 9–11.

Wild, H. "Die Regen-Verhältnisse des Russischen Reiches." (Monthly rainfall at Warschau, 1803–1882; Abo, 1749–1800. St. Petersburg, 1740–1882.) v. Suppl. Bd. Repert. Met., St. Petersb. 4to. St. Petersb., 1889. p. v — vii, xxii–xxiii, xxix–xxx.

Ziegler, Julius. "Niederschlagsbeobachtungen in der Umgebung von Frankfurt am Main nebst einer Regenkarte der Main- und Mittelrhein-Gegend." (Frankf. a. M., 1836–1885.) Jahresb. phys. Ver., Frankf. a. M., 1884–85. p. 57–115. 1 pl.

## LIST OF LONG RECORDS FROM THE MONTHLY WEATHER REVIEW.

### Precipitation.

Amherst, Mass. (1836–1887.) May, 1889. p. 134.
Charleston, S. C. (1738–1890.) Nov., 1890. p. 296.
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## PRECIPITATION AND TEMPERATURE AND THEIR EFFECTS ON CROP PRODUCTION IN TEXAS FOR THE YEAR 1893.*

I. M. Cline, M. D., Local Forecast Official, United States Weather Bureau.

### PRECIPITATION.

THE precipitation in Texas for the year 1893 was below the normal in all parts of the State except the panhandle district, where there was an excess amounting to 1.42 inches; and over this district there was a deficiency in January, March, April, June, and October. An unusual feature in the precipitation over the other six districts of the State is that there was a general deficiency in each month from January to April, inclu-

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sive, except that there was an excess amounting to .21 of an inch in January over Southwest Texas, and .55 of an inch in February and .75 of an inch in April over the coast district, and that the deficiency continued up to and including July over central Texas and up to and including May over Southwest Texas and the coast district.* From June to October, inclusive, there was a uniform and marked deficiency over North Texas, and also over West Texas except that there was an excess amounting to .24 of an inch in August. From July to October, inclusive, there was a marked deficiency in each month over North Texas, East Texas, Southwest Texas, and the coast district, while there was a marked deficiency over Central Texas during September and October. The deficiency was very large over nearly all parts of the State during April, September, and October. The rainfall in May fell generally between the 1st and 15th of the month.

No rain fell in June after the 19th; and none of any consequence fell during July. In fact the total amount of precipitation at most stations for the month of July was less than half an inch, particularly over Southwest Texas, Central Texas, and North Texas, which embraces the greater portion of the agricultural section of the State, while over other portions the amount was very unevenly distributed and averaged a little more than one inch. The rainfall for August was very well distributed but was slightly deficient over the greater portion of the State.

Only about one third of the normal rainfall occurred in September, and this fell generally on one day, in different parts of the State, between the 24th and 26th. No rain fell over the

*NOTE. On account of the extensive area covered by the State, the great distances between its geographical limits, and its varied climate, that part of the State east of the 100th meridian, which is mainly the agricultural portion, has been divided into five sections, and that to the west into two sections. This was done in order to enable more comprehensive discussions of the climatic features in their relation to agriculture and health.

The coast district embraces that part of the State below the 100-feet contour line of elevation; East Texas, that part between the 100-feet contour line of elevation and latitude 32° 30′, east of longitude 96°; North Texas, that part north of latitude 32° 30′, east of the 100th meridian; Central Texas, that part between longitude 96° and 100° and latitude 30° and 32° 30′; Southwest Texas, that part between latitude 30° and the 100 feet contour line of elevation west of the 96th meridian. West of the 100th meridian, that part north of latitude 34° is termed the panhandle, and that part to the south is termed West Texas.

greater portion of the State during October; there were a few scattered showers but these were of no consequence. In November there was an excess ranging from half an inch to two inches over East Texas, North Texas, Central Texas, and Southwest Texas, while it was deficient over other portions of the State. There was a general deficiency in December of one to two inches, except over western districts, and there was a slight excess over the panhandle and West Texas.

The following table shows the monthly rainfall for each district, and also the departures from the normal for each month for the year 1893:—

| | North Texas. | East Texas. | Central Texas. | Southwest Texas. | Coast District. | Panhandle. | West Texas. |
|---|---|---|---|---|---|---|---|
| January . . | 1.09 | 1.17 | 0.86 | 1.36 | 1.67 | 0.35 | 0.13 |
| February . | 1.13 | 1.00 | 0.56 | 0.87 | 2.80 | 1.28 | 0.02 |
| March . . | 1.87 | 2.90 | 1.63 | 1.50 | 1.17 | 0.31 | 0.67 |
| April . . . | 1.68 | 2.86 | 1.54 | 1.33 | 3.88 | 0.08 | 0.37 |
| May . . . | 6.64 | 5.68 | 4.72 | 3.10 | 3.12 | 1.58 | 2.53 |
| June . . . | 3.36 | 5.91 | 2.44 | 2.17 | 4.65 | 1.73 | 1.70 |
| July . . . | 0.81 | 1.20 | 0.32 | 0.42 | 1.66 | 1.70 | 1.09 |
| August . . | 2.56 | 2.06 | 3.26 | 1.10 | 2.39 | 3.97 | 2.74 |
| September . | 1.64 | 1.42 | 1.60 | 0.17 | 0.93 | 3.75 | 1.37 |
| October . . | 0.40 | 0.40 | 0.07 | 0.13 | 0.82 | 0.10 | 0.00 |
| November . | 2.89 | 4.88 | 3.55 | 4.89 | 3.89 | 0.55 | 0.40 |
| December . | 0.80 | 1.06 | 0.84 | 1.21 | 0.96 | 0.56 | 0.99 |
| Total . . | 24.77 | 30.54 | 21.39 | 18.25 | 27.94 | 15.86 | 12.01 |
| | *Departures from Normal.* | | | | | | |
| January . . | — 0.89 | — 1.98 | — 1.69 | + 0.21 | — 2.09 | — 0.11 | — 0.46 |
| February . | — 0.96 | — 3.14 | — 2.04 | — 1.16 | + 0.55 | + 0.79 | — 0.62 |
| March . . | — 0.03 | — 0.97 | — 0.88 | — 0.72 | — 2.21 | — 0.38 | 0.00 |
| April . . . | — 1.87 | — 1.01 | — 1.65 | — 2.13 | + 0.75 | — 1.01 | — 0.45 |
| May . . . | + 2.86 | + 0.93 | — 0.26 | — 0.36 | — 1.15 | + 0.33 | + 0.91 |
| June . . . | — 0.35 | + 2.01 | — 0.63 | + 0.14 | + 0.89 | — 0.17 | — 0.04 |
| July . . . | — 1.92 | — 1.11 | — 2.50 | — 1.45 | — 1.17 | + 0.20 | — 1.22 |
| August . . | — 0.86 | — 0.13 | + 0.29 | — 1.73 | — 1.49 | + 1.47 | + 0.24 |
| September . | — 2.25 | — 1.87 | — 2.35 | — 3.89 | — 4.90 | + 1.65 | — 1.52 |
| October . . | — 1.95 | — 2.89 | — 2.33 | — 0.90 | — 2.26 | — 1.15 | — 1.42 |
| November . | + 0.32 | + 1.14 | + 1.13 | + 2.67 | — 1.10 | — 0.09 | — 0.25 |
| December . | — 1.25 | — 2.58 | — 1.66 | — 0.06 | — 1.50 | + 0.06 | + 0.39 |
| Total . . | — 9.42 | —11.60 | —14.57 | — 9.38 | —15.68 | + 1.39 | — 4.24 |

Minus (—) below normal. Plus (+) above normal.

TEMPERATURE.

JANUARY. The temperature during this month was unevenly distributed and was generally one to three degrees above the normal except over the coast district, Southwest Texas, and the central portion of North Texas where there was a deficiency ranging from one to four degrees.

FEBRUARY. The temperature was generally one to seven degrees below the normal except over the extreme west and southeast portions of the State, where it was slightly above.

MARCH. The temperature averaged about two degrees below the normal except over the southwestern portion of the coast district, the north and northwest portions of Central Texas and the central portion of North Texas, where it was one to two degrees above the normal.

APRIL. The temperature averaged 4.5 degrees above the normal, with the greatest excess over Central Texas and the smallest over the eastern portion of the coast district.

MAY. The temperature was one to three degrees below the normal over the central portion of the coast district, the eastern portion of Central Texas, and the central and eastern portions of North Texas, while over other portions it was generally about normal but ranged from one degree below to one degree above normal.

JUNE. The temperature was one to five degrees above normal over Central and North Texas, while over other portions it was generally one to three below the normal.

JULY. The temperature was generally normal to four degrees above normal, except over the northern portion of East Texas, the southwestern portion of Central Texas, the central portion of the coast district, and the extreme western portion of the State, where it was one to four degrees below normal.

AUGUST. The temperature was one to three degrees below the normal over East Texas, the eastern portions of North, Central, and Southwest Texas, the central and eastern portions of the coast district, and the extreme western portion of the State, while over other portions it was 1 to 5 degrees above normal.

SEPTEMBER. The temperature averaged generally one to five degrees above the normal, and the excess during the early part of the month was very marked.

OCTOBER. The temperature was normal or slightly above, except over the southwestern portions of the State where there was a slight deficiency.

NOVEMBER. The temperature ranged from 1.2 degrees below normal over East, West, and Southwest Texas and the western portion of North and Central Texas to 3.3 degrees below over the coast district, while over other portions of the State it was normal or slightly above.

DECEMBER. The temperature was above normal in all parts of the State, and the excess ranged from two degrees over North Texas to 5.6 degrees over southern portions of the State.

## COTTON.

The weather during March was generally favorable for farm work, and the first three weeks of the month were devoted to preparing cotton lands, and this work was well advanced and planting under good headway in some parts of the State by the last of the month. Complaints were frequent from the southwestern portion of the State that dry weather was retarding planting. Dry weather prevailed generally over the State during April, which checked planting in the western portions of North and Central Texas and delayed the germination of seed over some other portions of the State. During the first half of May the rainfall was heavy and as a result very little work was done in connection with the cotton crop. The seed which had been planted came up well during and after these rains, and by the latter part of May the greater portion of the crop of the western portions of North and Central Texas had been put in the ground and a great deal of late cotton had been planted in various other parts of the State. During the first three weeks of June general and well distributed showers caused early-planted cotton to grow off fairly well, and brought up and started that part of the crop planted late. The growth of the young plant was retarded by the deficiency in temperature over portions of the State during May and June, but an excess of temperature over about one half of the State was very favorable to the crop.

On July 1, the plant was generally very uneven in size on account of the irregularity in time of planting; but as a whole, it looked very well; the stand was good and the fields were generally well cultivated. The outlook, however, was not con-

sidered favorable for the reason that the deficiency in precipitation since Jan. 1, 1893, was so marked that it would require an exceptionally favorable distribution of rainfall during the remainder of the season to make a good crop. During July no rain of any consequence fell, and this injured the crop seriously. The rainfall in August, which is one of the main cotton fruiting months, was about the normal and unusually well-distributed over Central, East, and North Texas, which brightened prospects over these sections, but the deficiency over other portions of the State was already showing its permanent effects. Considerable shedding was reported during August. About Sept. 1, an examination of the crops throughout the State showed that the plant, both early and late, was small and that the stage of development was very irregular everywhere. The unusual deficiency in rainfall during September cut late cotton short and completely cut off the top crop except in a few localities where there were sporadic showers which kept the crop growing.

The light rainfall in September, with no rain of any consequence during October, gave an exceptionally fine opportunity for picking, in fact the finest for years, and the crop was picked unusually close, which resulted in a much better yield than if the picking season had only been an average one.

In summing up the preceding conditions in their effects on the cotton crop, let us notice briefly the general features in the normal development of this product.

In the first place, cotton requires a good average season in the ground at the time of planting in order to enable it to stand unfavorable weather during the growing and fruiting months. The normal growth of the cotton plant presents a striking feature in the development of a long tap root which it sends down vertically until the moisture stored away in the earth during the winter season is reached. Besides the tap root, which is the main stay of the plant, there is a growth of surface roots which serve the purpose of firmly mooring and steadying the plant in its position and also assist in the assimilation of plant food from the atmosphere and the surface soil. When the season is such as to enable the plant to start its growth with a normal tap root it will withstand extremes of weather, drought or heavy rains. When there has been a large deficiency in the precipitation during the winter months no tap root forms, or only an imperfect

one, depending on the extent of the moisture supply in the ground, and there is then a large and abnormal development of the surface or lateral roots which show that the plant is making efforts to sustain itself on the current supply of moisture. The normal development of the product of the plant takes place something after the following manner: there is first the square, then the bloom, then the boll, and then the open cotton, which forms at the axils of the leaves, springing out from the angles made by the junction of the leaf with the twig. The boll has a stem like other fruits which is not firmly attached to the twig, but separated by a layer of plant tissue, something like the washer between two sections of piping or machinery.

This layer of tissue or natural washer governs to a certain extent the circulation of sap from the stalk to the boll, and also has certain uses in the assimilation of plant food, the discussion of which would be foreign to this subject. A close relation exists between the tap root and this layer of tissue in the performance of their natural functions. When there is no tap root, or only an abortive one, changes in weather from wet to dry, hot to cold, or conversely, cause as sudden changes in the growth of the plant, and cause it to grow less rapidly than the boll does or more rapidly than the boll does. In either case, as far as the present question is concerned, the effects are the same; the seam at the tissue layer opens, the cleavage is effected, and the boll or embryo fruit drops off, which is termed "shedding." When an axil has shed its germ, its career is ended, so far as fruit is concerned, as no germ will ever be formed there again. The phenomenon of shedding may be briefly described as an effort on the part of the plant towards husbanding its strength for the production of fruit further along the twig or higher up on the plant in case conditions should become more favorable.

When the tap root is well developed changes in the weather do not affect the growth of the plant nearly so rapidly. This has a tendency to keep the distribution of sap more regular during periods of abnormally wet or dry, hot or cold weather, and makes the fruit more abundant than it would be under such conditions when there is no tap root, and at the same time prevents shedding.

In the present season there was no tap root, which resulted from the deficiency in rainfall early in the season, while the rain

during May and June caused a rapid growth of surface or lateral roots. To have an average crop with this condition would have required about one inch of rain every ten days until the first of September, with the same moderate conditions of temperature which prevailed. Such was not the case, however, as has been noticed, and as a result this year's crop is only a little more than three fourths of an average, and would not have been this much except that the season for picking was unusually favorable.

CORN.

The corn crop is one which is not so long in making as cotton, and does not require exactly the same conditions of weather; but deficiency in precipitation during the winter months makes regular rains during the growing season necessary for a good yield.

The weather during March was generally favorable for corn planting, and the greater portion of the crop over the central and southern portions of the State, and about half of the crop over the northern portion, was planted before the middle of the month, and planting was done generally by the last of the month except over west portions where drought retarded work. Early planting was generally a good stand. The late planting did not come up quite so well as the early planting on account of the marked deficiency in rainfall, particularly over central and western portions of the State, and the plant generally became sickly and was suffering for rain by the last of April. Good rains during the early part of May gave corn a good growth and made it look healthy in nearly all parts of the State, while the latter half of the month was dry, and enabled farmers to clean the crop well. General and well distributed rains during the first three weeks in June insured a very good crop of early planted corn, but that planted late was cut very short by the drought which prevailed from June 20 to Aug. 1. While the corn crop was considerably shorter than usual, enough was raised for home consumption, with some to spare.

The weather was very favorable for gathering corn and the entire crop was housed to advantage.

WHEAT.

The panhandle and the western portions of North and Central Texas represent the greater portion of the wheat belt of the

State. The weather during November and December, 1892, was very favorable for putting in the wheat crop, and a much larger acreage than usual was sown. The weather was generally favorable for this crop, and it was very promising until the latter part of March, when the deficiency in rainfall which prevailed began to show its effects, and by the latter part of April the crop in many sections looked very bad, and had commenced heading with a very short stalk. Rains, which came during the early part of May, helped the late crop considerably, but hot winds during the latter part of May and the first few days of June damaged the late wheat to a marked extent and reduced the crop considerably, and also made a very poor quality of grain. Harvesting commenced about the middle of May, which is about the average time of commencement, and continued to the middle of June.

OATS.

The weather during February was very favorable for seeding oats and a large acreage was sown. The showers during March brought the crop up very well. This crop suffered considerably from the effects of drought during April, but the rains during the early part of May improved conditions materially in most sections, although they did not bring the crop up to an average. Harvesting was nearly completed during the first half of June. The crop was considerably short.

OTHER CROPS.

Truck gardens were generally very good, except those planted in February and March, which suffered from the effects of the dry weather. Fall gardens were a complete failure except where irrigated.

The fruit crop was generally good. Frost during the last ten days of March injured early peaches to some extent, but the damage did not amount to much, and the weather was generally as favorable for the fruit crop as could have been desired until toward the first of July, when the effects of the drought prevailing at that time resulted in some damage to peaches, apples, and pears.

The early forage crops were generally good. Farmers, however, raise the greater portion of their forage from fall crops, and the drought cut these very short.

# CURRENT NOTES.

*Royal Meteorological Society.* — At the meeting of this Society held on Wednesday evening, April 18, at the Institution of Civil Engineers, Great George Street, Westminster, Mr. Richard Inwards, F. R. A. S., the president, delivered an address on some phenomena of the upper air. He said that there are three principal ways in which the higher atmosphere may be studied: first, by living in it on some of the great mountain chains which pierce many miles into the air in various parts of the globe; second, by ascending into it by means of balloons; and third, by the study of the upper currents as shown to our sight by the movements of the clouds. After describing the effects of rarefied air on animal life and natural phenomena, Mr. Inwards proceeded to give an account of various balloon ascents which had been undertaken with the object of making meteorological observations. In 1850, Messrs. Barral and Bixio, when they had ascended to twenty thousand feet, found the temperature had sunk to 15° Fahr., but this was in a cloud, and on emerging from this three thousand feet higher, the temperature fell as low as *minus* 38°, or 70° below freezing point. In 1862, Mr. Glaisher and Mr. Coxwell made their famous ascent when they reached an altitude of about seven miles from the earth. A short time ago a balloon, without an æronaut, but having a set of self-recording instruments attached, was sent up in France, and from the records obtained it is shown that a height of about ten miles was attained, and that the temperature fell to *minus* 104° Fahr. Clouds are simply a form of water made visible by the cooling of the air which previously held the water in the form of invisible vapor. Every cloud may be regarded as the top of an invisible warm column or current thrusting its way into a colder body of air. After referring to the various classifications and nomenclatures of clouds, of which that proposed by Luke Howard in 1803 is still in general use, Mr. Inwards said that whatever system of naming and classifying clouds be adopted, it should depend on the heights of the various clouds in the air; and he gave a few rough rules by which the comparative altitudes of the clouds may be judged when there is no time or opportunity to make exact measurements. Among the indications by which a cloud's height in the air may be gathered are its form and outline, its shade or shadow, its apparent size and movement, its perspective effect, and the length of time it remains directly illuminated after sunset. By the last method some clouds have been estimated to have been at least ten miles above the surface of the earth. The cloud velocities at high altitudes have been carefully noted at the Blue Hill Observatory, Mass., U. S., and show practically that at about five miles' height the movement is three times as fast in summer and six times in winter, as compared with the currents on the earth's surface.

After showing a number of lantern slides illustrating the various types and forms of clouds, the aurora borealis, rainbows, etc., Mr. Inwards concluded his address by urging the desirability of establishing a good cloud observatory somewhere in the British Isles.

At the close of the meeting the Fellows and their friends inspected the exhibition of instruments, photographs, and drawings relating to the representation and measurement of clouds, which had been arranged in the rooms of the Institution. A lantern display of slides showing cloud effects and other meteorological phenomena was also given.

A monthly meeting of this Society was held on Wednesday evening, May 16, at the Institution of Civil Engineers, Westminster, Mr. R. Inwards, F. R. A. S., president, in the chair.

Mr. W. Ellis, F. R. S., read a paper, "On the relative frequency of different velocities of wind," in which he discussed the anemometer records of the Greenwich Observatory for the five years, 1888–1892, with the view of ascertaining the number of hours during which the wind blew with each of the different hourly velocities experienced during the period. The results of this discussion show that the wind blew for the greatest number of hours with the hourly velocities of ten and eleven miles.

Mr. W. Marriott, F. R. Met. Soc., gave an account of a series of observations on the "Audibility of 'Big Ben' at West Norwood," which he had carried on for a period of five years. The clock tower at Westminster is five and one-half miles distant from the point of observation in a north-by-west direction. The large bell "Big Ben" was designed by Lord Grimthorpe, and was cast in 1858; its weight is about fourteen tons. It is 9 ft. 5½ ins. in diameter, and 9⅜ ins. in thickness, its tone being E. The observations were 976 in number, and were made at the hours of 9 A. M. and 9 P. M. The bell could be heard more frequently in the evening than in the morning, and on Sundays it was more frequently audible than on week days. The direction of the wind most favorable for hearing "Big Ben" was between west and north. The observations were also discussed in relation to temperature, moisture, cloud, and barometric pressure.

A paper by Mr. A. W. Moore was also read on "Earth Temperatures at Cronkbourne, Isle of Man, 1880–1889."

*Protection from Lightning.* — A useful Circular of Information on "Protection from Lightning" has recently been issued by the Weather Bureau. It was prepared by Mr. Alexander McAdie by direction of the Secretary of Agriculture, and is designed to furnish information of practical value to all classes, especially to farmers, builders, and physicians. Mr. McAdie has given much study to the subject of lightning and lightning conductors, and is well fitted to speak with authority in this connection.

For several years various foreign countries have collected statistics regarding loss of life and damage to property due to lightning, and in 1891 the Weather Bureau undertook the systematic collection of such data. From a study of the statistics thus obtained it appears that the numbers of deaths due to lightning in the United States in 1890, 1891, 1892, and 1893, were respectively 120, 204, 251 and 209, or an average of 196 deaths a year.

These deaths by lightning practically all occurred between April and September, with a maximum in June and July. Regarding the damage done through fires caused by lightning, it appears that in the eight years ending with 1892 there were in the United States, and for the most part west of the Rocky Mountains, 3,516 fires thus caused, with a loss of $12,663,835. From these statistics it is seen that the damage done by lightning is a very considerable one, and that it is certainly worth while to erect proper protective apparatus. Lightning is more apt to strike in the country than in cities, and Mr. McAdie concludes from his studies that the risk in the country is as much as five times greater than in the city. For this reason it is stated that "for ordinary dwelling houses, not unduly exposed in city blocks, lightning rods are hardly necessary."

Lightning rods have a two-fold function, — to conduct the charge to earth and to prevent a disruptive discharge by a silent neutralization of the electrification of the clouds. In order to carry the lightning flash, "the lightning conductor should offer a line of discharge more nearly perfect, and more accessible than any other offered by the materials or contents of the edifice we wish to protect," and in order to prevent the discharge, "the conductor should be surrounded by points."

Several practical rules are given at the end of the report, the first of which is as follows: "Few questions have been so thoroughly discussed from practical as well as theoretical standpoints as that of the protection afforded by properly constructed lightning rods. All barns and exposed buildings should have lightning rods. Ordinary dwelling houses in city blocks have not the need for rods that scattered houses in the country, and especially if on hillsides, have." Directions are given as to the kind of conductor to be used, its proper adjustment, etc. Regarding the more popular aspects of the subject may be quoted the following: "Lightning does sometimes strike twice in the same place. . . . No good reason is known why a place that has once been struck may not be struck again. There are many cases on record supporting the assertion." "It is not judicious to stand under trees during thunderstorms, in the doorway of barns, close to cattle, or near chimneys and fire-places. On the other hand, there is not much sense in going to bed, or trying to insulate one's self in feather beds. Small articles of steel, also, do not have the power to *attract* lightning, as it is popularly put, or determine the path of discharge."

The circular concludes with a minute description of the lightning conductors on the Washington Monument in Washington; which, though a most dangerous exposure, has been uninjured by lightning since 1885, when the conductors were put in their present condition. The report is abundantly illustrated with views of conductors and fastenings, of damage done by lightning, and several fine half-tone plates of lightning flashes.

*A Rough Winter on Ben Nevis.* — In the April number of *Symons's Monthly Meteorological Magazine*, Mr. R. C. Mossman has a communication to the editor regarding the past winter on Ben Nevis, which is here reprinted: —

"The past winter has been so exceptionally wet and sunless over the more northern portion of the British Isles, that a summary of the meteorological conditions experienced at the Ben Nevis Observatory (4,407 feet above the level of the sea) may be of interest as showing how bad British weather can really be. We have extracted from the official returns in possession of the Scottish Meteorological Society the following particulars relative to rainfall and bright sunshine for the four months, Nov. 15, 1893, to March 14, 1894 — 119 days in all: —

| | |
|---|---|
| Rainfall (including melted snow) . . . . . | 104.39 ins. |
| No. of days .01 in. or more fell . . . . . | 110 |
| " " 1.00 " " . . . . . | 38 |
| Total bright sunshine . . . . . | 23.7 hrs. |
| Sunless days . . . . . | 107 |

"From Nov. 22, 1893, to Feb. 13, 1894, the bright sunshine recorded amounted to only four hours, December being sunless, except for one hour on the 1st. The only fine day during the four months was Feb. 14, when eight hours' sunshine was registered. Needless to say, the mountain was rarely free from mist during the above long period."

*A View of the Harvard College Station at Arequipa, and of the Misti.* — In the Vol. X. of this Journal, pages 282–287, Mr. A. Lawrence Rotch gave an account of the Harvard College meteorological station on Mt. Chachani, in Peru, which was at that time the highest meteorological station in the world. In the January number, pages 343–347, Prof. William H. Pickering gave an account of South American meteorology, based on his observations at Arequipa, and in the February number, pages 433, 434, we printed a translation of a letter published in *La Bolsa* by Prof. S. I. Bailey, giving an account of the establishment of a station on the Misti, 19,200 feet above the sea, at present the highest meteorological station in the world.

In view of the importance of the work that is being done at these stations, and of the interest that is generally felt in that work, we have already published, with Mr. Rotch's article, a picture of the Chachani station, and this month we are able to present our readers with a view of the Arequipa station from the southwest, with the Misti in the background. This picture gives a general idea of the Misti, on which Prof. Bailey has established his highest station. We are enabled to publish this view through the kindness of Prof. E. C. Pickering, Director of the Astronomical Observatory of Harvard College. It is reduced from a larger view, which is to be published in a forthcoming volume of the Annals of the Astronomical Observatory of Harvard College (Vol. XXVIII.).

*Weather Bureau Notes.* — The Chief of the Weather Bureau has been directed by the Secretary of Agriculture to visit the Great Lakes in order to further the work now going on in determining the set of the surface currents.

The University of Michigan at its recent Commencement conferred the degree of Doctor of Laws upon Mark W. Harrington, Chief of Weather Bureau.

THE HARVARD OBSERVATORY, AREQUIPA, AND THE VOLCANO EL MISTI.

Mr. James P. Sherry, an old and valued observer of the Weather Bureau, died July 11, at Cape Henry, Va. He was but recently promoted for meritorious services in connection with the stranding of the steamer "Rappahannock."

An article entitled "A Colonial Weather Bureau," appeared in "Popular Science Monthly" for June. The specially interesting points brought out are that Thomas Jefferson and James Madison made simultaneous observations of wind, pressure, and temperature in the years just preceding the war of Independence. Mr. Jefferson's observations of temperature made on July 4, 1776, in Philadelphia, are also given. These observations were previously unknown.

The demand for the Weather Bureau pamphlet, "Protection from Lightning," has been so great that a second edition was necessary.

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# CORRESPONDENCE.

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## NOTE ON DIFFUSION OF WATER VAPOR AND ON ATMOSPHERIC ABSORPTION OF TERRESTRIAL RADIATION.

*Editor of the American Meteorological Journal:*

In Prof. Harrington's notice of my "Elementary Meteorology" in this JOURNAL for April last, page 522, he comments adversely on my statements concerning diffusion of vapor and atmospheric absorption of terrestrial radiation. On the first of these subjects he says: "Is it correct to say that 'diffusion [meaning the dispersion of the molecules of the vapor of water] is a slow process' compared to convectional distribution? The diffusion here meant involves molecular velocities, under Dalton's law, and is very speedy." This refers to my statement on page 150 of the text-book to the effect that cloud making is more favored by the active convectional ascent of moist air than by the slow upward diffusion of vapor through the air.

It does not appear to me that my estimate of the relative activity of the two processes was wrong. Diffusion certainly depends on molecular velocities that are much faster than convectional movements; but the molecular velocities by which water vapor is distributed through the atmosphere cannot be considered as continually directed upwards from a surface of evaporation, such as that of the sea. The molecules of water vapor so frequently encounter the much more numerous molecules of oxygen and nitrogen that their movement becomes exceedingly irregular and their upward distribution is seriously retarded, and, as a result, the amount of vapor at a considerable altitude over the sea is much less than the amount which the theory of diffusion would lead one to expect. Hence it seems reasonable to regard diffusion as less effective in cloud making than the rather active and steadily upward ascent of convectional currents, whose operation is so often witnessed. Indeed, if the upward diffusion of vapor were more active than

convection, we should expect the sky of the trade wind zone to be continually covered by a sheet of cloud, day and night, while as a matter of fact it is a region of diurnal convectional clouds.

The following extracts may be cited in this connection: —

Dr. Julius Hann says: "The slow diffusion of aqueous vapor in the air alone prevents its rapid continued condensation in the upper strata. By reason of ascending currents of air, as well as any other cooling of masses of moist air, there occur, now here, now there, condensations of vapor, and under such conditions the existence of a state of equilibrium in the vapor atmosphere cannot be assumed." (Meteorological Memoirs, translated by Prof. C. Abbe, Smithsonian Report, 1877, p. 377.)

Prof. Wm. Ferrel wrote: "In the upper regions of the atmosphere the proportion of vapor in the atmosphere is less, both on account of the diminished temperature with increase of altitude, and also because evaporation takes place at the earth's surface and the vapor is very slowly diffused upward to high altitudes." ("Popular Treatise on the Winds," 102.)

The words "slow" and "slowly" would hardly have been used by these writers if they had had molecular velocities in mind.

Prof. Harrington's second comment refers to the following statement, on page 31 of my book: "Just as the rays from the sun warm the surface of the earth, so the rays emitted from the surface of the earth in the day time aid in raising the temperature of the air. Terrestrial rays, however, are weak compared to solar rays, and they are not actively absorbed by the atmosphere, but pass out through clear air with about as little loss as the solar rays suffered on entering through it. . . . It has been supposed that the air was a better absorber of terrestrial radiation than of solar radiation, and thus the atmosphere has been compared to a trap which allowed sunshine to enter easily to the earth's surface, but prevented the free exit of radiation from the earth."

Concerning this, Prof. Harrington remarks: "Is it quite correct, as stated on page 31, that 'terrestrial rays [that is, heat radiated from the earth] . . . pass out through clear air with about as little loss as the solar rays suffered on entering through it'? The terrestrial rays are generally dark rays, which are readily absorbed by the air. It is the rays reflected from the upper cloud surfaces, and also to some extent from snow, water, and desert surfaces, that pass back with small absorption."

The only satisfactory source of original information on this complicated subject that I have met is the series of memoirs by Prof. S. P. Langley. Other physicists have investigated the wave lengths and transmissibility of the radiant energy of the solar beams, either directly on their way from the sun, or after being diffusely reflected or scattered by various terrestrial substances. Langley's studies alone have sufficiently measured the wave lengths and transmissibility of beams emitted by actual radiation from relatively cold bodies, like the earth, the air, and the moon. As to wave length, these studies have shown that the lunar spectrum, as well as that received from terrestrial radiators, is extremely coarse compared to that received from the sun, or from sunlight reflected from the moon or earth; the two

classes of spectra being so unlike as to have distinctly separate *loci* for their maximum energy on the spectroscopic scale.

The question at issue is the relative absorption by the atmosphere of the rays of these dissimilar spectra; but before considering this, I may quote the following paragraph from Langley's address, "The History of a Doctrine": "About ten years ago, it was generally believed that the earth's atmosphere acted exactly the part of the glass in a hot bed, and that it kept the planet warm by exerting a specially powerful absorption on all *infra*-red rays. . . . Accordingly, when my own experiments did not agree with the received statement, I concluded that my experiments must be wrong, and made them all over again, till spring, summer, autumn, and winter had passed, each season giving its own testimony, and this for successive years. The final conclusion was irresistible, that the universal statement of this alleged well-known fact, inexplicable as this might seem in so simple a matter, was directly contradicted by experiment. . . . Fourier simply takes this * (in which he is wrong) for granted; but as he is an authority on the subject of heat, his words are repeated without criticism, first by Poission, then by others, and then in the text books; and, the statement gaining weight by age, it comes to be believed absolutely, on no evidence whatever, for the next sixty years, that our atmosphere is a powerful absorber of precisely those rays which it most freely transmits." ("American Journal of Science," xxxvii., 1889, 19, 20.)

I am not sure whether Prof. Harrington's criticism refers to this theory of Fourier's in which terrestrial radiation is assumed to be similar to the *infra*-red rays of the solar spectrum; or whether it refers to the point that I had in mind while writing, namely, to the absorption by the atmosphere of the truly terrestrial rays, which Langley has shown to be of excessively great wave length, without recognizable representation in the spectrum of the sun. Prof. Harrington's phrase: "The terrestrial rays are generally dark rays" would seem to favor the first of these alternatives; for the rays that are really radiated by the earth are without exception "dark"; indeed, very dark. Their wave length is exceedingly great compared to the coarsest optical rays.

Coming back now to the main question, we may consider first the absorption of solar rays by the atmosphere.

Langley concludes that about half of the solar energy is lost in passing down through the air. He presents a curve which represents the distribution of energy in the spectrum of the high sun at Allegheny; the area included between the curve and its horizontal base line, corresponding to 1.7 on a scale of calories. Another curve constructed on the same base, but with ordinates representing the inferred distribution of energy in the solar spectrum outside of the atmosphere, encloses an area corresponding to 3.5 calories. ("Researches on Solar Heat," Prof. Papers, Signal Service, XV., 144, and plate XV.) It is in this connection that Langley explicitly states that atmospheric absorption of solar radiation is not, as has been commonly

* The opacity of the air to the *infra*-red rays.

supposed, greater for rays of longer wave length ("dark heat rays," in the misleading terminology commonly employed), but is greater at the other end of the spectrum. It should be noted, however, that Langley uses the term *absorption* in a general sense to mean the total loss suffered by the rays in passing down through the atmosphere; and he remarks that the loss suffered by the fine-waved rays may be occasioned by lateral scattering on fine suspended particles, as explained by Lord Rayleigh, instead of by actual absorption of solar rays followed by re-radiation of locally formed coarser-waved rays.

The second point concerns the absorption of terrestrial or lunar rays by the atmosphere; it being carefully understood that no reflected solar rays are here included, but only those actually excited by the action of terrestrial or lunar molecules on the adjacent ether. Information on this difficult subject may be found in Langley's memoir on the Temperature of the Moon read before the National Academy of Sciences, November, 1887, and published in abstract in the "American Journal of Science," December, 1889, pages 421 to 440; in full in the Memoirs of the National Academy, Vol. IV., part 2.

The following extracts may be made from the first of these sources: "It has also been almost universally supposed that our atmosphere was nearly impervious to the lunar radiant heat, so that if any existed, it could still not be perceived by us at the sea-level" (page 422). Yet as the later pages of the article show, the lunar spectrum is by no means nearly all absorbed by our atmosphere. The atmosphere "exercises, in this part of the spectrum as in every other, a highly selective absorption, indicated here, however, not by fine lines like the Fraunhofer lines of the solar spectrum, but by enormously wide 'cold bands'" (page 429). These cold bands of the lunar or terrestrial spectrum are proved to be due to selective atmospheric absorption by their occurring at wave lengths corresponding to those of the "spectrum of the midnight sky"; Langley having actually succeeded in the extraordinary feat of detecting the relative intensity and wave lengths of rays emitted by the air at night. The atmospheric rays and the cold band of atmospheric absorption are both chiefly in the region of 7 $\mu$; but the lunar spectrum has a considerable extension towards wave lengths of even greater dimensions; the discovery of these rays being one of the triumphs of Langley's work. The observed intensity of the awakened lunar spectrum after passage through the atmosphere and the inferred intensity of the normal lunar spectrum are plotted in full and dotted curves in a figure (plate XI.), from which it may be inferred that about half of the lunar rays are lost in coming to us; the greater part of the loss being in the region of 7 $\mu$, or the "cold band" already mentioned. The rays of greater wave length are not reduced on the average by more than a fifth or a quarter of their normal intensity. The total loss of the lunar rays does not appear to be quite so much as half their normal intensity, and this measure is not unlike that suffered by solar rays. Hence it seems to me that my statement concerning solar and terrestrial radiation should stand.

The extended essay, printed in the Memoirs of the National Academy, is concerned more with a detailed statement of the methods of observation and

discussion than with a concise summary of results; it does not add materially to the points already quoted; but it is noted that "very little difference was found in the apparent transmission of the solar and of the lunar beam by the earth's atmosphere as inferred from comparisons at high and low altitudes above the horizon" (page 108). The diagram giving curves to represent the observed intensity of the lunar spectrum and the inferred intensity outside of the atmosphere, is referred to as being constructed on the assumption of a transmission of half the total lunar radiation; but the text states that the best measures indicate that 38% are transmitted, and hence 62% are absorbed. This is somewhat more than in the case of the total solar radiations; but the difference is not of a considerable amount. It should be understood that a very slight haziness greatly increases the loss of lunar rays on their way down through the atmosphere, and similarly impedes the outward passage of radiation from the earth. It is also concluded from certain experiments that the atmosphere is practically opaque to the rays of the cold band in the neighborhood of 7 $\mu$; the absorption that it exercises on these rays being essentially completed in a moderate thickness of air.

The facts here stated were in grave doubt before Langley's later studies, as appears from his own assertion: "If the mean surface temperature of the globe be taken at 15° or 16° C., unless we could form an energy spectrum from heat of some such degree as this, and determine the maximum ordinate of its curve, we should, in my view, be unable to determine the approximate wave length of the heat in question, *to which I believe our atmosphere is sensibly impermeable;* yet it is on the retaining of this extremely low kind of heat that the organic life of our globe, it seems to me, largely depends." (Prof. Paper, Signal Service, No. XV., page 134. The italics are mine.) Later studies show that the atmosphere is very sensibly permeable to these rays.

W. M. DAVIS.

HARVARD COLLEGE, June 4, 1894.

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## FESTOONED, MAMMIFORM, AND POCKY CLOUDS.

*Editor of the American Meteorological Journal:*

In the "Monthly Weather Review" for March last, the editor, Prof. Abbe, makes extracts from letters from Dr. J. C. Neal concerning the occurrence of "a peculiar cloud formation" that he has noted for some years as a prognostic of tornadoes. He thinks they may be "relied upon as invariably present from thirty minutes to two hours before the tornado." Dr. Neal is quoted as describing these clouds as "characterized by ball-like masses of a light gray or white color, often in long lines on a darker background or in clumps, often three or more side by side, the under side circular, the upper indefinite or shading into the main cloud." Prof. Abbe describes a drawing of these clouds, not published in the "Review," by saying "the under surface of the cloud layer is thickly studded with what is known in the English nomenclature as 'mammiform' clouds, otherwise called mammoid, mam-

mato-cumulus, globo-cumulus, pocky cloud, rainballs, or festooned cumulus. A mammiform cumulus is supposed to mark the central region of a comparatively small whirling mass of air, such as might, under favorable circumstances, develop into a water spout or tornado."

I am prompted to make a brief note on this matter for the JOURNAL, because it seems to me that a different interpretation of Dr. Neal's report is permissible, if not necessary.

A brief statement of the terminology of pocky or festooned clouds may be found in "Science" for Jan. 15, 1886, page 57, in which clouds of this kind are explained as resulting from the slow settling of cloud sheets into lower air; this explanation being accepted by several authors there quoted, as well as indicated by several observations of my own in connection with thunderstorms. Further brief statement of similar tenor may be found in "Science," Jan. 29, 1886, by H. H. Clayton; "Science," Feb. 5, 1886, by H. W. P., who wrote that festoon clouds were strikingly exhibited on the "under surface of the high advanced sheet overhanging the memorable tornado that destroyed Iowa College and one third of the town of Grinnell"; they were observed also on other occasions, both with and without thunderstorms; finally in "Science," Feb. 12,1886, by J. M. Allen, who described a remarkable group of festoon clouds in connection with a thunderstorm cloud at Martha's Vineyard, Mass. I may also refer to an account of these clouds in my "Elementary Meteorology," in which their form and their association with thunderstorms are illustrated.

Now these various examples, cited under the name of festoon cloud, pocky cloud, mammiform cloud, etc., certainly should not be associated in origin with any whirling mass of air, such as might develop into a tornado, as suggested by Prof. Abbe. It is true that the festoon clouds are commonly associated with thunder clouds; but they appear characteristically as pendents from the higher parts of the cloud, not from the lower part where the tornado funnel is developed; they show no whirling motion, but only a very slow settling. In some thunderstorms I have seen what might be called large festoons, more disorderly and more rapidly dissolving and changing form than the sand-bag type of festooned cirrus. An example of these is given in the "Bulletin" of the New England Weather Service for June, 1892, reprinted in this JOURNAL for September, 1892, 231, where they are described as "descending or inverted cumulus clouds, settling down, as if they had toppled over from an ascent elsewhere, writhing and twisting as they entered the lower air, and progressively dissolving away as they descended."

If it be admitted that, with the exception of the last citation, all these examples refer to true festoon clouds, then it seems to me wrong to associate any whirling or incipient tornado-motion with these clouds. If on the other hand the clouds referred to by Dr. Neal possess a whirling motion (such as is suggested by Prof. Abbe, although not reported by Dr. Neal) they should not be called festoon clouds. Incipient whirls among the clouds are often described in connection with accounts of tornadoes and water spouts; but they commonly have a downward-pointing extremity, in-

stead of being rounded downward; they exhibit great activity of disorderly motion; in no case that I have noted are they associated with high-level clouds, but only with low heavy cloud sheets. While I have thus far escaped witnessing a tornado, I have occasionally seen imperfect whirls in the under surface of thunderstorm cumuli; but they did not bear any resemblance to what I should call festoon clouds.

As regards the relation of festoon clouds (to which I believe Dr. Neal's account really had reference) to tornadoes, it seems probable enough that tornado-bearing thunderstorms usually possess festoons on the under surface of their lofty and extended cirro-stratus sheet; but it does not seem at all probable that all storms in which festoons appear will also possess tornadoes. Tornadoes are relatively rare; festooned clouds are truly not often recorded in descriptions of clouds, but I believe that they are relatively common; and that they would appear more frequently in meteorological records if a place were prepared for them in the adopted terminology. The necessity of conforming in routine observations to a relatively brief and simple terminology of clouds is manifest enough; but it is equally manifest that no great advance can be made in our knowledge of clouds or of the processes with which they are associated, as long as only the conventional terms for naming and describing them are employed. A very useful extension of the official terminology might be made by adopting a systematic series of adjectives, by which the names of clouds now in use might be qualified; thus encouraging those observers who wish to specialize in this direction to utilize their observations further than is possible under the present restricted terminology; but at the same time allowing routine observations to continue in the condensed form now customary.

Festoon clouds are a case in point. They are certainly not rare in connection with the thunderstorms of the Mississippi Valley. From what I can gather, they are rather definitely associated with the cirro-stratus sheet of thunderstorm cloud masses, and not with other parts. Observers in our central States may easily test this conclusion, and I hope many will join Dr. Neal in his intention of making a special study of the question this year.

W. M. DAVIS.

HARVARD COLLEGE, June, 1894.

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## A DEVICE TO FACILITATE THE ACCURATE READING OF THE BAROMETER.

*Editor of the American Meteorological Journal:*

In reading my barometer, I have heretofore always been troubled to make an exact contact of the vernier and top of the mercurial column on account of the white light reflected from its convex surface. I find that by joining a paper with a dead black surface to a piece of white paper, and placing it behind the barometer at such a height that the dividing line is about the mark of thirty-one inches, the black above, a perfectly black shadow is thrown on the meniscus and it stands out sharp and well-defined against

the white background, and there is no difficulty in securing a perfect apparent contact between the vernier and mercury.

I. H. LEVY, D. D. S.

Franklinville, N. J., May 2, 1894.

# BIBLIOGRAPHICAL NOTES.

## TITLES OF RECENT PUBLICATIONS.

Furnished by Mr. Oliver L. Fassig, Librarian, U. S. Weather Bureau, Washington, D. C.

(An asterisk [*] indicates that the publication thus designated has been received by the Editor of this Journal.)

*Alabama Weather Review and Agriculturist. March, 1894. Contained in *Alabama, a monthly paper devoted to the industries and to the development of the resources of Alabama.* Vol. I. No. 1. Fol. Montgomery, Ala., 1894.

*Batavia. Magnetical and Meteorological Observatory. *Observations.* Vol. XV. 1892. Published under the direction of Dr. J. P. Van Der Stok. Fol. Batavia, 1893. 214 pp.

Batavia. Magnetical and Meteorological Observatory. *Rainfall in the East Indian Archipelago.* Fourteenth year, 1892. 8vo. Batavia, 1893. 413 pp.

*Bremen. Meteorologische Station I. Ordnung. Deutsches Meteorologisches Jahrbuch für 1893. *Ergebnisse der meteorologischen Beobachtungen.* Hrsg. von Dr. Paul Bergholz. Jahrgang IV. 4to. Bremen, 1894. VI., 40 pp. 8 pl.

*Cline, J. L. *Crop production in Texas compared with temperature and precipitation departures for eight years.* Special Bulletin, No. 2. Texas Weather Service. 8vo. Galveston, 1894. 8 pp.

*Indian Meteorological Memoirs. Vol. VI., Part I. No. 1. *The relation between sunspots and weather as shown by meteorological observations taken on board ships in the Bay of Bengal during the years* 1856 *to* 1879. No. 2. *Investigation into the mean temperature, humidity, and vapour tension conditions of the Arabian Sea and Persian Gulf.* Fol. Calcutta, 1894. 88 pp. 19 pl.

Japan. Central Meteorological Observatory. *Annual report for the year* 1891. Part II. Memoirs. 4to. Tokio. (n. d.)

Contents: —

1. *Climatic Review for the year* 1891. 12 *pp.* 26 *pl.*
2. *On the low and high Areas of Pressure, and Gales in the year* 1891. 12 *pp.* 24 *pl.*
3. *Verifications of Indications and Storm Warnings in the year* 1891. 6 *pp.*
4. *On the Precipitations in the year* 1891. 4, 15 *pp.* 4 *ch.*
5. *On the Earthquakes in the year* 1891. 16 *pp.* 4 *pl.*
6. *Meteorological Observations on the Summit of Mount Ontake.* xx, 20 *pp.* 10 *pl.*
7. (108 *pages of Japanese text.*)

Japan. Central Meteorological Observatory. *Annual Report for the year* 1892. Part I. *Meteorological Observations in Japan.* 4to. Tokio (n. d.). 185 pp.

Manson, Marsden. *The importance of North Pacific weather stations. The features of our storms and their interpretation.* (Read before the Science Association of the University of California, April 11, 1893.) 8vo. (San Francisco, n. d.) 11 pp. 5 pl.

Prussia. K. Preuss. Meteorol. Institut. *Ergebnisse der Niederschlagsbeobachtungen im Jahre* 1892. Fol. Berlin, 1894. xlv, 192 pp. 2 pl.

*ROUMANIA. INSTITUTE MÉTÉOROLOGIQUE. *Annales de L'Institute Météorologique de Roumanie pour l'annee* 1891. Publiées par Stefan C. Hepites. Tome VII. 4to. Bucarest, 1893.

*ROUMANIA. INSTITUTE MÉTÉOROLOGIQUE. *2ème. Résumé des Observations Météorologiques de Bucarest (Filaret) pour les années* 1891 *et* 1892 *et pour la periode de* 1885 *à* 1890. (Extr.) Annales inst. met. Roumanie, Bucarest, VIII., 1892, c318–c338.

ST. PETERSBURG. PHYSIKALISCHES CENTRAL-OBSERVATORIUM. *Annalen.* Hrsg. von H. Wild. Jahrgang, 1892. 4to. St. Petersburg, 1893.

ST. PETERSBURG. K. AKADEMIE DER WISSENSCHAFTEN. *Repertorium für Meteorologie.* Red. von Dr. H. Wild. Band XVI. 4to. St. Petersburg, 1893.

CONTENTS: —

No. 1. H. ABELS. *Beobachtungen der taeglichen Periode der Temperatur im Schnee und Bestimmung des Waermeleitungsvermoegens des Schnees als Function seiner Dichtigkeit.* 53 *pp.*

No. 2. H. WILD. *Instrument für Erdmagnetische Messungen und astronomische Ortsbestimmungen auf Reisen.* 27 *pp.* 1 *pl.*

No. 3. M. RYKATSCHEW. *Der taegliche Gang der Temperatur der Luft in den Tropen der Oceane.* 45 *pp.* 1 *pl.*

No. 4. H. WILD. *Die Normalbarometer des physikalischen Central Observatoriums zu St. Petersburg.* 25 *pp.* 3 *pl.*

No. 5. O. CHWOLSON. *Actinometrische Untersuchungen zur Construction eines Pyrheliometers und eines Actinometers.* 158 *pp.* 1 *pl.*

No. 6. E. BERG. *Beobachtungen der Schneedecke und der Schneegestoeber im Winter* 1890 *auf* 1891 *im Russischen Reiche.* 41, lxxix *pp.* 1 *pl.*

No. 7. W. DUBINSKY. *Resultate einer Pruefung des Barographen Sprung-Fuess im Observatorium zu Pawlowsk.* 53 *pp.*

No. 8. E. LEYST. *Untersuchungen ueber den taeglichen und jaehrlichen Gang der meteorologischen Elemente an den Cyclonen und Anticyclonen Tagen.* 363 *pp.* 2 *pl.*

No. 9. H. WILD. *Jahresbericht des physikalischen Central Observatoriums für* 1892. 94 *pp.*

No. 10. *Zusammenstellung der Beschluesse der Internationalen Meteorologen Conferenzen, von der Conferenz in Leipzig, August,* 1872, *bis und mit der Conferenz in Muenchen, August,* 1891. 61 *pp.*

KLEINERE MITTHEILUNGEN.

I. H. WILD. *Der Sommer* 1892 *und der Winter* 1892 *auf* 1893 *in St. Petersburg,* 5 pp.

II. A. PREBRASHENSKAJA. *Bericht ueber die Bora in Noworossysk vom* 3–9 *Januar,* 1893. 7 pp.

III. A. SCHOENROCK. *Ein merkwuerdiger Temperatursprung in der Umgegend von St. Petersburg am* 11 *Februar,* 1893. 10 pp.

IV. E. STELLING. *Ueber stoerende electrische Einfluesse beim Bifilarmagnetometer.* 4 pp.

V. A. KARAMSIN. *Die Temperatur der Luft auf dem Gute Polibino.* 8 pp.

SWITZERLAND. SCHWEIZERISCHE METEOROLOGISCHE CENTRAL-ANSTALT. *Instruktionen für die Beobachter der meteorologischen Stationen der Schweiz.* Zweite umgearbeitete und vermehrte Auflage. Hrsg. von der Direktion der Schweiz. Met. Anstalt. 8vo. Zürich, 1893. 48 pp.

SWITZERLAND. SCHWEIZERISCHE METEOROLOGISCHE CENTRAL-ANSTALT. *Annalen der Schweizerischen meteorologischen Central-Anstalt.* 1891. 28 Jahrgang. 4to. Zürich (1893). 387 pp. 12 pl.

TORONTO. MAGNETICAL OBSERVATORY. *General Meteorological register for the year* 1893. 8vo. (Toronto, 1894.) 11 pp.

U. S. WEATHER BUREAU. *Report of wrecks which occurred on the Great Lakes from Dec.* 17, 1885, *to Nov.* 15, 1893. 8vo. Washington, D. C., 1894. 22 pp. Chart, 24 x 32 in.

VAUCLUSE. COMMISSION MÉTÉOROLOGIQUE. *Compte rendu pour l'annee* 1893. 4to. (Avignon, 1894.) 27 pp. 1 pl.

## PUBLICATIONS RECEIVED.

(In addition to those marked with an asterisk from month to month under Titles of Recent Publications.)

Casella, L. Automatic Recording Instruments (Système Richard Frères), patented throughout the world, for Science, Engineering and Commerce. Illustrated and Descriptive Catalogue, L. Casella, Agent for Richard Frères of Paris. 147 Holborn Bars, London, E. C. 4to. 1894. 48 pp. (An admirable catalogue, containing views and descriptions of the famous Richard Instruments.)

Casella, L. List, with Notes, of Standard Meteorological and other Instruments for Observatories, Travellers and Explorers, and the Army and Navy. L. Casella, 147 Holborn Bars, London, E. C. 8vo. 72 pp.

Mossman, R. C. Results of Meteorological Observations taken at Edinburgh during 1893. Reprinted from the Proceedings of the Royal Physical Society of Edinburgh, Vol. XII, 1894, pp. 336–349, 1 pl. (Contains remarks on the meteorology of 1893; an account of the warm spring and summer of 1893; noteworthy phenomena in the meteorology of 1893; full tables of meteorological data for the year and an interesting plate showing the weekly fluctuation of pressure, wind direction, sunshine, temperature and rainfall. Mr. Mossman's studies show that the mean temperature of March, April and May, 1893, exceeded the average by 3.6° Fahr., being absolutely the warmest during the past one hundred and thirty years. The nearest approach to this spell of spring warmth was in 1779, when the mean for these three months was 3.2° above the average.)

Wesley, Wm. and Son. The Natural History and Scientific Book Circular. No. 115. Meteorology, Physical Geography and Aeronautics. 8vo. London, 1892. (A catalogue of meteorological publications for sale by Messrs. Wm. Wesley and Son, 28 Essex St., Strand, London. It contains the titles of many valuable works on meteorology, well classified.)

Uruguay. Sociedad Meteorologica Uruguaya. Revista mensual de meteorológica práctica. Tomo II. Num. 3 and 4, Marzo-Abril, 1893.

Monthly Bulletins. Alabama Weather Review and Agriculturist; California (the February number contains some interesting notes on Experiments on Thermometer Exposure by H. S. Channing, Frost Notes, by S. H. Gerrish, and Frost Records and Minimum Temperature Comparisons); Colorado; Iowa; Iowa State Board of Health; Kansas; Louisiana Weather Journal and Agriculturist; Maryland; Nebraska; New Jersey; New York; North Carolina; North Dakota; Oklahoma; Pennsylvania; Tennessee Journal of Meteorology; Texas; Utah; Wisconsin Weather and Crop Journal.

Crop Bulletins. Alabama; Iowa; Maryland; Mississippi; Kansas; North Carolina; Oklahoma; Pennsylvania; Tennessee; Texas; Utah.